

SYLLABUS AND SCHEME OF EXAMINATION
MASTER OF SCIENCE
(NATURAL RESOURCE MANAGEMENT)
(ACADEMIC SESSION AUGUST 2012 ONWARDS)



GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY
SECTOR-16C, DWARKA, NEW DELHI-110078

SYLLABUS AND SCHEME OF EXAMINATION

- **Programme Code:** 247
- **Title of the Programme:** Master of Science (Natural Resource Management)
(Implemented from August 2012)
- **Academic Council's Approval:** 32nd Meeting (2012)
- **University School of Studies of the Programme:**
University School of Environment Management (USEM)
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M. Sc. (Natural Resource Management)

PREFACE

Natural Resource Management (NRM) Degree

Natural Resource Management (NRM) is an integrated and multidisciplinary approach combining Earth-Science, Life-Science, Environmental Science, Social Science and Management Science to manage and restore natural resources and ecosystems. Natural Resource Management sustains and restores abiotic and biotic resources within wilderness, forestry, recreational, agricultural and urban areas and the skills to address management problems. Natural Resource Management helps to balance the needs of people and the economy with protecting the ability of ecosystems to support soil, water, forests, wildlife, fish, recreation, and other resources. Natural Resource Management professionals are trained to look for ways to make responsible natural resource management decisions which consider all stakeholders. The degree requires two years of study (Four Semesters)

Relevance:

The Natural Resource Management program will increase the University School of Environment Management School Educational Programme for higher studies. The Natural Resource Management (NRM) curriculum requires an in-depth understanding of the subjects of Environmental Degradation and Unsustainable Consumption of Resources. There are only a few Universities in India that offer courses about NRM. There are huge infrastructures and extensive economic development is being planned in India, to maintain and promote economic growth. Natural resources are key components for the growth and prosperity of the nation. Such courses will develop contemporary expertise with domain knowledge which will help students through there advanced curriculum. The University may have professional linkages with U.S. Universities in the field of Environment Management to strengthen research and teaching programme. Such contemporary courses will supply the manpower required for industries, sectoral business and for future knowledge development.

Examination

The University has adopted the semester system for this programme. In addition to the End Term Examination, there is a continuous evaluation of student's performance throughout the academic programme. The Odd Semester Examinations are conducted in the months of December-January and the Even Semester Examinations are conducted in the months of May-June.

Evaluation and Award of Degree

The overall weight of a course in the syllabi and Scheme of Examination is determined in terms of credits assigned to the course. Obtaining a minimum of 50% marks in aggregate in each course, including the End Term Examination and the teacher's continuous evaluation, is essential

to earn the assigned credits. A student who secures less than 50% of marks in a course is, therefore, deemed to have failed in that course. A student is eligible for the award of University degree, if he/she has registered himself/herself, has undergone the regular course of studies, completed the project report/dissertation specified in the curriculum of his/her programme within the stipulated time, and has secured the minimum number of credits as prescribed for the award of concerned degree.

Broad Guidelines for Question Paper

The question papers are key tools for assessing student learning. Question papers are very meticulously planned to cover the entire course and include all components of assessment:

- 1) Knowledge
- 2) Comprehension
- 3) Application
- 4) Analysis and Evaluation
- 5) Synthesis
- 6) Creativity and Innovation

Instructions to Paper Setter

1. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.

2. Apart from question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, the student may be asked to attempt only 1 question from each unit. Each question should be worth 12 possible marks.

SCHEME OF EXAMINATION
Master of Science (Natural Resource Management)

FIRST SEMESTER

Course Code	Course Title	L	T	P	Credits
Theory Papers					
EMNRM-601	Fundamentals of Natural Resources	4	0	0	4
EMNRM-603	Ecology and Ecosystems: Moving towards Sustainability	4	0	0	4
EMNRM-605	Earth and Water Resources	4	0	0	4
EMNRM-607	Biodiversity and Biosystematics	4	0	0	4
EMNRM-609	Environment, Energy and Technology	4	0	0	4
EMNRM-611	Natural Resource Governance and Policy	3	0	0	3
Practical / Viva Voce					
EMNRM-651	Environmental Monitoring Analysis	0	0	4	2
EMNRM-653	Biodiversity Assessment and Taxonomy	0	0	4	2
	Total	23		08	27

SECOND SEMESTER¹

Course Code	Course Title	L	T	P	Credits
Theory Papers					
EMNRM-602	Natural Resource Economics	4	0	0	4
EMNRM-604	Geospatial Technology for NRM	4	0	0	4
EMNRM-606	Society, Ethics and Participatory Development	3	0	0	3
EMNRM-608	Statistical Analysis and Computer based Data Handling	3	0	0	3
EMNRM-610	Environmental Impact Assessment (EIA) and Auditing	3	0	0	3
EMNRM-612	Livelihoods and Natural Resources	3	0	0	3
Practical / Viva Voce					
EMNRM-652	Remote Sensing and GIS	0	0	4	2
EMNRM-654	Computer based Statistical Analysis in NRM	0	0	4	2
EMNRM-656	Vegetational Inventory and Rapid Assessment: Tools and Techniques	0	0	4	2
	Total	20		12	26

Summer Training for Six Weeks¹

1. After the 2nd Semester students will undergo summer training for six weeks in different industries / institutes.

THIRD SEMESTER

Course Code	Course Title	L	T	P	Credits
Theory Papers					
EMNRM-701	Financial Analysis, Project Management and Planning	3	0	0	3
EMNRM-703	Climate Change and Carbon Trading	3	0	0	3
EMNRM-705	Agro-ecosystems and Agro-forestry	3	0	0	3
EMNRM-707	Wildlife Conservation and Management	3	0	0	3
EMNRM-709	Research Methodology and Development Communication	3	0	0	3
EMNRM-711	<i>Summer Training Report and Seminar²</i>	0	0	0	3
*Electives					
EMNRM-751	Urban Forestry, Biodiversity and Landscape	3	1	0	4
EMNRM-753	Wetland Management	3	1	0	4
EMNRM-755	Advanced Remote Sensing and GIS	3	1	0	4
EMNRM-757	Environmental Modelling	3	1	0	4
EMNRM-759	Ecotourism and Other Environmental Services	3	1	0	4
EMNRM-761	Bio-resources	3	1	0	4
EMNRM-763	Watershed Management	3	1	0	4
	Total	21	2	0	26

**The student is required to opt for only two electives, out of above which are compulsory.*

²The summer training reports will be evaluated in two parts. The organizations under whose guidance the summer training project has been completed, shall award marks out of 50. The remaining 50 marks will be awarded by an Internal Board of Examiners as per the rule of the University.

FOURTH SEMESTER

Course Code	Course Title	L	T	P	Credits
Theory Papers					
EMNRM-702	Seminar and Progress Report ³	4	0	0	4
EMNRM-704	Dissertation ⁴	0	0	0	22
	Total				26

³ Evaluation will be based on the report and a presentation in the presence of at least three faculty members of the School duly approved by the Vice-Chancellor.

⁴ The student will submit a synopsis in a specified format at the beginning of the semester, to be evaluated for approval by the departmental committee. The student will have to present the progress of the work through seminars and progress reports. Evaluation of the dissertation will be based on thesis and viva/voce by the Board of Examiners comprising of the External Expert and the Internal Supervisor. The names of the External Examiners shall be approved by the Vice-Chancellor by the recommendations of the Dean.

Total No. of Credits offered in all four semesters⁵ - 105

⁵ The student will require to earn 100 credits for the award of the degree. The student will not have the option to drop any course covered in the scheme of the examination he/she will be required to register all the courses listed in the scheme of the examination of the programme.

FIRST SEMESTER

Course Code: EMNRM-601

L:4 T:0 C:4

Course Title: **FUNDAMENTALS OF NATURAL RESOURCES**

UNIT-I

Introduction to Natural Resource Bases: Concept of resource, classification of natural resources. Factors influencing resource availability, distribution and uses. Interrelationships among different types of natural resources. Concern on Productivity issues. Ecological, social and economic dimension of resource management.

UNIT-II

Forest resources: forest vegetation, status and distribution, major forest types and their characteristics. Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people, forest management. Developing and developed world strategies for forestry.

Land resources: Land as a resource. Dry land, land use classification, land degradation, man induced landslides, soil erosion and desertification. Landscape impact analysis, wetland ecology & management.

Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. Water ecology and management.

Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies

Food resources: World food problems, changes caused by agriculture and over-grazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case-studies.

Fish and other marine resources: Production, status, dependence on fish resource, unsustainable harvesting, issues and challenges for resource supply, new prospects.

UNIT-III

Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.

Resource Management Paradigms: Resource management the evolution and history of resource management paradigms.

Resource conflicts: Resource extraction, access and control system.

Approaches in Resource Management: Ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies.

Poverty and implications in Resource Management in developing countries – Poverty in developing countries, causes and link with resources scarcity and poverty.

UNIT-IV

Management of Common International Resources: Ocean, climate, International fisheries and management commissions; Antarctica: the evolution of an international resource management regime.

Case Studies:

1. Resource management in mountain ecosystem
2. Dry-land ecosystem
3. The management of marine and coastal resources
4. Case study of shifting cultivation
5. Mangrove ecosystem and their management

Recommended Books:

Text Book:

1. **Francois Ramade 1984.** Ecology of Natural Resources. John Wiley & Sons Ltd.
2. **Odum, E.P. 1971.** Fundamentals of Ecology. W.B. Saunders Co. USA, 574p

Reference Book:

1. **Coastal Ecology & Management, Mann, K.H. 2000.** Ecology of Coastal Waters with Implications for Management (2nd Edition).Chap. 2-5, pp.18-78 & Chap. 16, pp.280-303.
2. **Global Change and Natural Resource Management, Vitousek, P.M. 1994.** Beyond global warming: Ecology and global change. Ecology 75, 1861-1876.
3. **Agarwal, K.C., 2001.** Environmental Biology, Nidhi Publication Ltd. Bikaner.
4. **Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001,** Environmental Encyclopedia, Jaico Publishing House.
5. **Heywood, V.H. & Watson, R.T. 1995.** Global Biodiversity Assessment.Cambridge Univ. Press.
6. **Miller T.G. Jr.** Environmental Science, Wadsworth Publishing Co. (TB)
7. **Townsend C., Harper J, and Michael Begon.** Essentials of Ecology, Blackwell Science.

FIRST SEMESTER

Course Code: EMNRM-603

L: 4 T:0 C:4

Course Title: **ECOLOGY, ECOSYSTEMS TOWARDS SUSTAINABILITY**

UNIT-I

Introduction: Definitions, history and relevance, levels of ecology, types of ecosystem, abiotic and biotic environments, biotic – abiotic interactions, UNESCO scheme of soil classification.

Population ecology: Population attributes, population changes, survivorship curves, growth models, demographic models, dispersion

Community ecology: Community structure, two-species interactions, food webs, succession

UNIT-II

Ecosystems ecology: Climate and weather, energy flows, productivity, nutrient cycling, hydrological cycling, cycling index, biogeochemical cycles (C, N, P, S).

Ecosystem conservation: Ecosystem degradation, ecosystems rehabilitation, watershed management, population abatement in lentic and lotic environments, forest types in India, forest management, wildlife management, protected area categories: national parks, sanctuaries, Community and biosphere reserves.

UNIT-III

Global ecology/ Threats to Ecosystems: Greenhouse effect and climate change, ozone depletion, ecosystems responses to long-term climate patterns

Sustainability: Sustainability theory, the underlying ecological imperative, carrying capacity, sustainability and society (social justice, development, economy), Sustainable Forest, Management, Agenda-21 and UNEP programmes towards sustainable development.

UNIT-IV

Ecosystem based Case-studies: Ecosystem based case studies on mountain and coastal ecosystem.

Ecosystem Services: Scope, application, model and examples from India and outside.

Recommended Books:

Text Book:

1. **Primack, Richard B. 2010.**Essentials of Conservation Biology, 5th edition. Sinauer.
2. **Odum, Eugene P., and Gary W. Barrett. 2007.** Fundamentals of Ecology, 5th edition. Thomson Brooks / Cole.

Reference Book:

1. **Gotelli, Nicholas J. 2008.** A Primer of Ecology, 4th edition. Sinauer.
2. **Stiling, Peter. 2001.** Ecology: Theories and Applicatios, 4th edition. Prentice Hall.
3. **Rogers, Peter P., Kazi F. Jalal, and John A. Boyd. 2007.** An Introduction to Sustainable Development. Earthscan.

4. **Edwards, Andres R. 2005.** The Sustainability Revolution: Portrait of a Paradigm Shift. New Society.

FIRST SEMESTER

Course Code: EMNRM-605

L: 4 T: 0 C: 4

Course Title: **EARTH AND WATER RESOURCES**

UNIT-I

Earth Resources: Atmosphere, lithosphere, hydrosphere Interior of Earth, geological work of wind and water, underground water, igneous, sedimentary and metamorphic rocks, mineral types, mineral resources of India, erosion and weathering, soil formation, soil profiles, types of erosion, estimation of soil loss, landuse and landuse planning, earth resource mapping and the use of remote sensing and GIS

UNIT-II

Water Resources: hydrology, the hydrological cycle and its components, drainage systems, classification of water resources, characteristics of water resources. Surface run-off, stream flow estimation, problems of water and ground water resource depletion, watershed types and Functions

UNIT-III

Natural Hazards: Flood types and causes, drainage basins, nature and frequency of floods, effects. Flood hydrographs., types and causes of landslides, coastal hazards including cyclones, tsunamis, the effects of tides and tidal effect prediction, earthquake seismology, causes, intensity and magnitude of earthquakes, geographic distribution of earthquakes zones, nature of destruction, causes and consequences of forest fires

UNIT-IV

Applications for management: Soil and water conservation measures, erosion control, case studies in water resource conservation and management, flood management and control, landslide control and mitigation measures, coastal zone management, watershed management and case studies, earthquake mitigation for buildings and dams, forest fire mitigation and management, RS and GIS techniques in forest fire mapping, management hazards such as controlled burns escaping,

Recommended Books:

Text Book:

1. **Roy, A.B. 2010.**Fundamentals of Geology.Narosa.
2. **Singh, Rajvir. 2000.** Watershed Planning and Management. Yash.

Reference Book:

1. **Wallace, John M., and Peter V. Hobbs. 1997.** Atmospheric Science : An Introductory Survey, Academic Press.
2. **Bocker, Egbort, and Rienk Van Grondille, 1999.**Environmental Physics.John Wiley & Sons.
3. **Murthy, V.V.N. 2009.** Land and Water Management, 5th edition.Kalyani Publishers.
4. **Heathcote, I.W. 1988.** Integrated Watershed Management: Principles and Practice.John Wiley.
5. **Raganuth, H.M. 2007.** Hydrology: Principles, Analysis and Design, 3rd edition. New Age International.
6. **Dennen, William H., and Bruce R. Moore. ?**Geology and Engineering.Wm C Brown Publisher

FIRST SEMESTER

Course Code: EMNRM-607

L: 4 T:0 C: 4

Course Title: **BIODIVERSITY AND BIOSYSTEMATICS**

UNIT-I

Introduction to biodiversity: Definition, components, scope, and constraints of biodiversity (genetic diversity, species diversity, ecosystem diversity – agro-biodiversity, urban – peri-urban biodiversity), forest biodiversity; biodiversity indices, threats to biodiversity.

UNIT-II

Plant and animal taxonomy and systematics: Brief history and definition, the importance of taxonomy in Natural Resource Management, national and international organizations associated with taxonomic studies.

UNIT-III

Theory and practice of biological classification: Definition and problems of the species concept, intraspecific categories, super species, population structure and taxonomic challenges, 13 phenetic, cladistic and evolutionary concepts involved in nomenclature, taxonomic hierarchy.

UNIT-IV

Reference collections: Importance and all biological studies, collection methods, methods of specimen preservation and storage, identification and annotation histories, The International Rules of the Botanical and Zoological Nomenclature, the biosystematics and its future directions.
Biodiversity Conservation – Approaches: Landscape approach to biodiversity conservation, Corridor approach, individual species approach, habitat conservation approaches, National Biodiversity Strategy and Action Plan.

Recommended Books:

Text Book:

1. **Krishnamurthy, K.V. 2003.** Textbook of Biodiversity. Science Publications.
2. **Primack, R.2006.** Essentials of Conservation Biology. Sinauer associates, Inc., USA

Reference Book:

1. **Judd, W.S., C.S. Campbell, E.A. Kellogg, P.A. Stevens and M.C. Donoghue. 2008.** Plant Systematics: A Phylogenetic Approach, 3rd edition. Sinauer.
2. **Simpson, G.G. 1962.** Principles of Animal Taxonomy. Oxford.
3. **Mayr, E and P.D. Ashlock. 1991.** Principles of Systematic Zoology. MacGraw-Hill.
4. **Narendran, T.C. 2006.** An Introduction to Taxonomy. Zoological Survey of India, Kolkata.

5. **Kapoor, V.C. 1998.** Theory and Practice of Animal Taxonomy. Oxford and IBH Publishing.

FIRST SEMESTER

Course Code: EMNRM-609

L: 4 T:0 C:4

Course Title: **ENVIRONMENT, ENERGY AND TECHNOLOGY**

UNIT-I

Introduction to energy: Definition and units of energy, power, forms of energy, second law of thermodynamics, solar spectrum, solar radiation, extraterrestrial radiation, effect of atmosphere, estimation of solar radiation on horizontal and tilted surface analysis of Indian solar radiation data and applications

Energy consumption: Exponential increase in energy consumption, energy resources including coal, oil, natural gas, nuclear power, wind, and hydroelectricity, impact of energy consumption on global economy, future energy options and challenges

UNIT-II

Environmental impacts: Fossil fuel impacts and patterns of consumption, renewable electricity and key elements, global climate change, CO₂ and renewable energy, social considerations, standalone systems and grid integration

Indian energy: Commercial and non-commercial forms of energy, energy consumption patterns as a function of time, energy resources available in India, urban and rural energy consumption, nuclear energy promise and problems, wind and other emerging new technologies, energy as a factor limiting growth, importance of renewable energy sources

UNIT-III

Environmental pollution: Primary and secondary pollution, air, thermal and water pollution, depletion of the ozone layer, global warming, controlling thermal power pollution, controlling pollution due to nuclear power generation, radioactive waste and its disposal, hydroelectric power stations effect on the environment

Environmental impacts: Fossil fuel, renewable electricity and key elements, hydropower and its constraints, wind energy: technology and economics, solar power, photovoltaic technology, biomass, tidal power, OTEC

UNIT-IV

Rural energy/Biomass to energy: Wood energy/ fuel wood use, Biochemical conversion, sources of energy generation, industrial waste, agro residues, anaerobic digestion and biogas production, thermo-chemical conversions, gasification and types of gassifires, briquetting, ethanol, bio-gas

Bio-diesel: History, production methods, trans-esterification, fuel quality, standards and properties, raw materials and applications, bio-diesel potential in India, ecological impacts of bio-fuel cultivation.

Recommended Books:

Text Book:

1. **Tiwari, G.N. and M. K. Ghosal. 2005.** Renewable Energy Resources: Basic Principles and Application, Narosa Publishing.
2. **Ginley, David S., and David Cahen.** 2011. Fundamentals of Materials for Energy and Environmental Sustainability. Cambridge.

Reference Book:

1. **Master, Gilbert M. 2004.**Renewables and Efficient Electric Power Systems. John Wiley and Sons.
2. **Boyle, Godfrey. 2004.** Renewable Energy, 2nd Edition. Oxford University Press.
3. **Twidell, I. John and Tony Weir. 2007.** Renewable Energy Resources. Taylor and Francis Group.
4. **Tiwari, G.N. 2002.** Solar Energy. Narosa Publishing.

FIRST SEMESTER

Course Code: EMNRM-611

L: 3 T:0 C:3

Course Title: **NATURAL RESOURCES GOVERNANCE AND POLICY**

UNIT-I

Introduction: Legal and political environments in resource management. Global and local governance, challenges of good governance. Ostrom design principles and basic frameworks, organizational structure and stakeholders in NRM and livelihood. Natural Resource Governance in rapidly changing world.

Local utilization and institutions: Joint Forest Management Committees (JFMCs), watershed committees, irrigation committees, Forest Rights Act (FRA) committees, Biodiversity Management Committees (BMCs), etc.

UNIT-II

Overview of legal policy instruments in Natural Resource Management: National Forest Policy of 1988, National Environment Policy of 2004, National Conservation Policy, National Action Plan on Climate Change of 2008, Coastal Protection Act. Wildlife Protection Act of 1972, Forest Protection Act of 1980, Environment Protection Act of 1986, ICZM-Indian Coastal zone management, Water Act, 1981. Biological Diversity Act of 2002 and Rule 2004, Forest Rights Act of 2006. Green Tribunal Act, 2009. The precautionary principle and common responsibilities.

Non-Timber Forest Products (NTFP) related policies and other acts: (PESA 1996, FRA 2006), sustainable harvesting rules of MP, Nistar Rights in MP and Chhattisgarh, product-specific policies, taxation, Institutional/Organizational Arrangements. NTFP Deregulation, Policy of Odisha.

Conflicts in resource management: Resource management planning, protecting traditional knowledge, customary laws and practice related to traditional knowledge, implications for access benefit sharing

UNIT-III

International and National efforts: CITES and other international treaties and conventions, roles of international organizations and NGOs with special reference to UN and specialized agencies, institutional regulatory bodies and authorities: direct intervention by the state, green business and green ethics, stakeholder analysis, understanding and managing governance issue, governance tactics and tools, CSR (Corporate Social Responsibility) as a tool for sustainable NRM based business.

Case studies about corporate social responsibility

- Corporate social responsibility (CSR)
- NRM based CSR action
- E-governance
- Climate change and corporate responses

Recommended Books:

Text Book:

1. **Knight, Richard L., editor, et al. 1995.** A New Century for Natural Resources Management. Island Press.
2. **Heal, Geoffrey. 2000.** Nature and the Marketplace: Capturing The Value Of Ecosystem Services. Island Press.

Reference Book:

1. **Bhattacharya P., Kandya A.K. and Krishna Kumar 2008.** Joint Forest Management in India, Aavishkar Publisher, Jaipur.
2. **Daily, Gretchen, editor, et al. 1997.** Nature's Services: Societal Dependence On Natural Ecosystems. Island Press.
3. **Kareiva, Peter, et al. 2011.** Natural Capital: Theory and Practice of Mapping Ecosystem Services. Oxford.
4. **Kareiva, Peter, and Michelle Marview. 2010.** Conservation Science: Balancing the Needs of People and Nature. Roberts and Company.

FIRST SEMESTER

Course Code: EMNRM-651 Practical

P :2 T:0 C:2

Course Title: **ENVIRONMENTAL MONITORING ANALYSIS (SOIL, WATER, MINERAL, AIR AND FUEL)**

Water Analysis: Dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), Ph, turbidity, hardness, heavy metals

Soil Analyses: Soil Ph, conductivity, moisture content, soil organic carbon content, dead wood and forest litter carbon estimation.

Fuel technology- proximate analysis of fuel (coal, wood samples), calorific values of solid and liquid fuel.

Rocks and minerals- identification of various types, forms their characteristics

Atmosphere Analyses: Sox, Nox, and suspended particulate matters, carbon dioxide content of a gas sample and climate change

Results: Students will understand how these parameters are calculated, what they mean, and how to interpret them

Books Recommended:

Text Book:

1. **Singh, D., P.K. Chhoker and R.N. Pandey.** Plant, Water Analysis: a Methods Manual. IARI.
2. **Helmer, Richard. 1998.** Water Pollution Control: A Guide to the Use of Water Quality Management Principles. Spon Press.

Reference Book:

1. **Ritter, William F. 2000.** Agricultural Nonpoint Source Pollution: Watershed Management and Hydrology. CRC Press.
2. **Harmancioglu, Nilgan B. 2003.** Integrated Technology for Environmental Monitoring and Information Production (NATO Science Series IV: Earth and Environmental Sciences). Springer.
3. **Thompson, K. Clive. 2004.** Environmental Toxicity Testing. Blackwell.

FIRST SEMESTER

Course Code: EMNRM-653 Practical

P:2 T:0 C:2

Course Title: **BIODIVERSITY ASSESSMENT AND TAXONOMY**

Field techniques: Biodiversity component are assessed, monitored and identified through numerous features, methods and scientific application.

- Techniques of preparation of Herbarium and museum specimens.
- Collection and preservation techniques of animal
- Description and Identification of selected plant families.
- Techniques of Biodiversity Monitoring- different life forms- insects, amphibian and reptiles
- Population indices
- Ethno-botanical approach of understanding biodiversity value
- Analyzing biodiversity component from Bio-fertilizers- vermin-compost, nitrogen fixers, micorrhiza
- Biodiversity indicators

Book recommended:

Text Book:

1. **Pullin, A.S. 2002.** Conservation Biology, Cambridge University Press, Cambridge.
2. **Kapoor, V.C. 1998.** Theory and Practice of Animal Taxonomy, Oxford and IBH Publishing.

Reference Book:

1. **Simpson, G.G. 1961.** Principles of Animal Taxonomy, Oxford Book Company, Kolkata
2. **Lawrence, G.H.M. 1964.** Taxonomy of Vascular Plants. Oxford & IBH Publishing co. Calcutta.
3. **Mary, E and P.D. Asholock. 1991.** Principles of Systematic Zoology, MacGraw-Hill, inc., New Delhi

SECOND SEMESTER

Course Code: EMNRM-602

L: 4 T:0 C: 4

Course Title: Natural Resource Economics

UNIT-I

Natural resources: Types and classification of natural resource, concept of Economic value, relevance of environmental economics, ecosystems services, direct and indirect economic benefit from – forest ecosystems, mountain ecosystems, mineral and water resources, ecotourism.

Valuation and accounting: Supply and demand, conservation and management, cost / benefit analysis, methods of costing, cost criteria, evaluating alternative projects, operational vs. total costs, determining benefiting vs. comprehensive stakeholders Application of resource accounting Methods of pricing resources- example forest and mineral resources.

UNIT-II

Economic resource theory and applications: Concept of CPR, open access, Ecological economics-methodology, economic valuation of non market benefits, environmental accounting, population resources and the environment, command and control vs. emission trading, emission trading vs. exposure trading, hotelling principle, future strategies for mineral resources.

UNIT-III

Natural Resource Management market: Initial concept of market and marketing, NRM sectors product marketing and their roles, promoting NRM products- NTFPs, livestock, watershed, fisheries, agriculture and medicinal plants and ecotourism, Role of national and international organizations in the promotion of sustainable natural resource use and management.

UNIT-IV

Case studies related to resource economics-

1. Payment for ecosystem services
2. Watershed economics
3. Mineral
4. Sustainable fisheries
5. Forest certification

Recommended Books:

Text Book:

1. **Barber, E. 1989.** Economics: Natural Resources Scarcity and Development. Earthscan.
2. **Harris, J.M. 2006.** Environmental and Natural Resource Economics: A Contemporary Approach, 2nd edition. Houghton Mifflin.

Reference Book:

1. **Biergeford, L.E. 1993.** Natural Resource Tenure: A Review of Issues and Experiences With Emphasis on Sub-Saharan Africa. International Rural Development Centre.
2. **Field, Barry C. 2008.** Natural Resource Economics An Introduction. Waveland Press.

3. **Houand, Daniel S, Au.** Economic analysis for ecosystem-based management: application to marine and coastal environments: Washington, RFF Press, USA.

SECOND SEMESTER

Course Code: EMNRM-604

L: 4 T: 0 C: 4

Course Title: **GEOSPATIAL TECHNOLOGY FOR NRM**

UNIT-I

Introduction to Remote Sensing: Definition, physical basis of remote sensing, electromagnetic spectrum, radiation laws, atmospheric effects, basics of optical, thermal and microwave remote sensing, history of remote sensing, resolution types, EMR interaction with surface materials, spectral signatures of different objects, platforms and sensors. Characteristics of Landsat, SPOT, IRS, ERS, Radarsat and other operational remote sensing satellites. Visual image interpretation tools and techniques

Digital Image Analysis: Digital image processing, geometric corrections, digital image classifications, integration of multispectral and multi temporal images, image transformations, ground truth verification and data collection

UNIT-II

Introduction to Geographic Information System (GIS): Basic concepts and components of GIS, geographic information and spatial data types, geographic phenomena, geographic field, geographic objects and boundaries, Raster based GIS data processing with both regular and irregular tessellations, Vector based GIS data processing and topology, spatial relations, spatial analysis, database design and organization

UNIT-III

Introduction to Global Positioning Systems (GPS): Basics of GPS mappings and software, satellite generation, positioning services, GPS details and integration, map projections, coordinate systems, sources of information and map elements, types of Survey of India (SOI) topographical maps, numbering systems of SOI maps, interpretation of SOI topographical maps, GIS and image processing software

UNIT-IV

Applications and case studies in NRM: Coastal zone management, disaster management, forestry and wildlife management, landform studies, land use/cover mapping, tracking water resources (surface and underground water mapping), weather monitoring, snow and glacier studies, mineral resources, mine impact studies, agriculture. The future trends in applications

Recommended Books:

Text Book:

1. **Lillisand, Thomas, Ralph W. Kiefer and Jonathan Chipman. 2007.** Remote Sensing and Image Interpretation. Wiley India.
2. **Jensen, John R. 2004.** Introductory Digital Image Processing: A Remote Sensing Perspective. Prentice Hall.

Reference Book:

1. **Jensen, John R. 2009.** Remote Sensing of the Environment: An Earth Resource Perspective, 2nd Edition. Dorling Kindersley.
2. **Joseph, George. 2005.** Fundamentals of Remote Sensing, 2nd Edition. University Press India.
3. **Sabins, Floyd F. 2007.** Remote Sensing: Principle and Interpretation. Waveland Press.
4. **Janssen, Lucas L.F., and Grrit C. Huurneman. 2001.** Principle of Remote Sensing. ITC Educational Text Book series 2.International Institute of Geoinformation Science and Earth Observation (ITC).Enschede.
5. **Lo, C.P., and Albert K.W. Yeung. 2009.** Concepts and Techniques of Geographic Information Systems, 2nd Edition. PHI Learning.
6. **Longley, Paul A., Michael F. Goodchild, David J. Maguire and David W. Rhind. 2005.** Geographic Information System and Science, 2nd Edition. John Wiley and Sons.
7. **Burrough, P.A. 2007.** Principles of Geographic Information System.Oxford University Press.
8. **de Rolf, A. 2001.** Principles of Geographic Information System.ITC Educational Text Book series 1.International Institute of Geoinformation Science and Earth Observation (ITC).Enschede.
9. **Fazal, Shahab. 2008.** GIS Basics. New Age International Publishers.

SECOND SEMESTER

Course Code: EMNRM-606

L: 3 T: 0 C: 3

Course Title: **SOCIETY, ETHICS AND PARTICIPATORY DEVELOPMENT**

UNIT-I

Role of society in NRM: Theory of participation, cultural ecology, ecological and sacred landscapes, conflicts, behavioral dimensions of participatory management, ethics in resource management, low carbon lifestyles, case studies. Participatory approaches to development. Participatory Rural Appraisals (PRA) methods, their purpose and applications.

UNIT-II

Participatory Development: Introduction to common property resources, village economics and the evolution of participatory institutions, economic evaluation of investment with people's participation, participatory linkages: participatory designs –a cluster-based approach, participatory resource management, planning and monitoring

The Ethics of development: ethical frameworks, multiple stakeholders, community involvement, alternative forms of community investment, ethical code for development projects.

UNIT-III

Sustainable natural resources management and development: Industrialization and its impacts, growth vs. inclusive growth, societal impacts, types of farming systems, globalization, urbanization and privatization, sustainability of modern developments: dams and displacement, mining, high impact agriculture

Recommended Books:

Text Book:

1. **Cernea, M.M. 1985.** Putting People First: Sociological Variables in Rural Development. Oxford.
2. **Simonsen, Jesper and Toni Robertson.** 2012. Routledge International Handbook of Participatory Design (Routledge International Handbooks).Routledge.

Reference Book:

1. **Chopra, K., K.G. Kadekodi, and M.N. Murthy. 1990.** Participatory Development: People and Common Property Resource. Sage Publications.

SECOND SEMESTER

Course Code: EMNRM-608

L: 3 T:0 C:3

Course Title: **STATISTICAL ANALYSIS AND COMPUTER BASED DATA HANDLING**

UNIT-I

Data management and graphical presentation: Tabulation and organization of data, graphical presentations including line graphs, bar graphs, pie charts, histograms, box plots, data cleaning and validation

Descriptive statistics: Measures of central tendencies including how to calculate and advantages and disadvantages of each method, measures of variation including coefficients of variation and the differences between standard deviations, standard errors, and confidence intervals, covariance, distributions including the standard normal distribution and its application, z scores, deviation from normality and when to use parametric vs. nonparametric methods, skewness and kurtosis

UNIT-II

Correlation and Regression: Correlation analysis, correlation coefficients for ungrouped data, Spearman's rank scatter diagrams, differences between correlation and regression and prediction, regression coefficients (partial and interactions), applying regression coefficients, estimating variability at different positions on the regression line.

UNIT-III

Group comparisons and statistical inference: Types of tests and experimental design, Students t distribution, test of significance of single mean, two means (2t) and paired t test, Z vs. T tests, Chi square test, goodness of fit, F test and ANOVA, one way and two way ANOVA, Q test, nonparametric tests, Mann Whitney U test, Kruskal Wallis test

Recommended Books:

Text Book:

1. **Cochran, W.G. and G.W. Snedecor. By K. Koehler, 2012** Statistical Methods, 8th edition. Iowa State University Press.
2. **Stell, R.G. and J.H. Torrie. Date** Principles and Procedures of Statistics. McGraw-Hill.

Reference Book:

1. **Ostle, Bernard and R.W Mensisng.** Statistics in Research. Iowa State University Press.
2. **Goulden, C.H.** Methods of Statistical Analysis. Nabu Press.
3. **Rangaswamy, R.** Textbook of Agricultural Statistics. New Age International.

SECOND SEMESTER

Course Code: EMNRM-610

L: 3 T:0 C:3

Course Title: **ENVIRONMENTAL IMPACT ASSESSMENT (EIA) AND AUDITING**

UNIT-I

Introduction to EIA: Definition and objectives of EIA, purpose of EIA, terminology, hierarchy in EIA, basic data collection for EIA

Legislation and framework: EIA legislative requirements and administrative procedures in India/Indian States, EIA notification of MOEF, 2006 National Environmental Policy Act and implementation

UNIT-II

Public participation in environmental decision making: Regulatory requirements, techniques, advantages and disadvantages of public participation, managing a public hearing

Impact assessment techniques and methodology: Description of the environmental setting, methods of impact analysis, environmental risk assessment, baseline data collection

Prediction and assessment of impacts: Air, Gaussian plume model for air pollution assessment, water, noise, biological, cultural and socio-economic damage.

Case studies of EIA for Industries: Oil, petrochemical, fertilizer, sugar and distilleries, mining industries (iron and steel, cement industry)

Case studies of development: Roads, dams and housing, denial cases for development projects based on EIA clearance.

UNIT-III

Environment Management Plan: Planning, selection of appropriate procedures, introduction to budget, minimizing environmental impacts

The Environmental Audit: Environmental auditing and its importance, types of audits, general audit methodology and basic auditing structure, ISO14000 requirements of Rule 14 for Environmental Audit under Environmental Protection Act of 1986, definitions of. Consumption audits, pollution audits, hazardous issues audits, voluntary audits

Recommended Books:

Text Book:

1. **Canter, Larry W.** Environment Impact Assessment. McGraw-Hill.
2. **Rau, G.J. and C.D. Weeten. 1980.** Environmental Impact Analysis Handbook. McGraw Hill.

Reference Book:

1. **Glasson, John, Rikki Therievel and Andrew Chadwic. 1996.** Introduction to Environmental Impact Assessment, 2nd edition UCL Press.

2. **Kulkarni, Vijay and T.V. Ramchandra. Date** Environmental Management. Capital Publishing.
3. **Mhaskar, A.K.** Environmental Audits. Enviro Media Publications.
4. **Eccleston, Charles H. 2011.** Environmental Impact Assessment: A Guide to Best Professional Practices. CRC Press.
5. **Morris, Peter and Riki Therivel. 2009.** Methods of Environmental Impact Assessment (Natural and Built Environment Series). Routledge.

SECOND SEMESTER

Course Code: EMNRM-612

L: 3 T:0 C:3

Course Title: **LIVELIHOODS AND NATURAL RESOURCES**

UNIT-I

Introduction to livelihoods and relation with Natural Resource Management (NRM):

Concepts and scope of livelihood, livelihood framework analysis, various capitals involved, indigenous communities and traditional livelihoods, forms of natural resources and dependencies of local people, natural resource crisis impacts on the livelihood of people, ecological, sociocultural and economic dimensions, threats of traditional livelihood from globalization, urbanization, privatization, and migration, climate change impacts, mitigation and adaptation

Non-Timber Forest Products (NTFP) as a source of rural livelihood: NTFP types, classification and distributions, first step survival strategy, policies and acts to support NTFP activities, importance of sustainable resource management, with case studies

UNIT-II

People's participation in forestry: Joint Forest Management in India: background, need and focus, policy perspective and implementation methods, various dimensions (ecological, social and economic) of joint forest management, scope of livelihood generation under JFM, with case study on JFM Linking scope of Rural Development with livelihoods , Rural Development Approaches for livelihood support, Analysis of NRM Matrix.

Rural Development Programme and Schemes – MNREGA Components of NRM and RD, SGSY, DRDP, WFP, Integrated Rural Development Programme, Rural Livelihood Programmes and Projects. NRM Programme and Schemes- National Afforestation Programme (FDA), DPIIP, Man and Biosphere Programme, Bamboo Mission, Medicinal Plant Conservation and Cultivation Projects (NMPB), Biofuel Mission, Rural Livestock Development Programmes, Horticulture and Agriculture Development Programmes.

UNIT-III

Cases studies on NRM-based Livelihood Development for Enhanced Income Generation

- Community Based Coastal Fishery Management – A Case from Sri Lanka
- Bamboo Based Enterprise Development – Case Study of Bamboo Mission
- Wet Rice Cultivation – A traditional Practice amongst Apatani Tribe of Arunachal Pradesh
- Bio fuels Plantation for Rural Development.
- Livestock Management – CAPLI Programme- Small Ruminants Rearing
- Ecotourism Initiative for Community Development – Kerala State Forest Dept.
- Alpine medicinal plant trade and Himalayan mountain livelihood strategies

Recommended Books:

Text Book:

1. **Shackleton, Sheona, Charlie Shackleton, and Patricia Shanley, (editors) 2011.** Non-Timber Forest Products in the Global Context (Tropical Forestry).Springer.
2. **Malhotra, KC and Prodyut Bhattacharya. 2010.** Forest and Livelihood. Pub. Centre for Economic and Social Studies. Hyderabad.

Reference Book:

1. **Food and Agricultural Organization, United Nations. 1997.** Domestication and Commercialization of Non-Timber Forest Products in (Non-Wood Forest Products).
2. **Broekhoven, Guido. 1996.** Non-timber Forest Products: Ecological and Economic Aspects of Exploitation in Colombia, Ecuador, and Bolivia. World Conservation Union.
3. **Prodyut Bhattacharya, A.K. Kandya and Krishna Kumar. 2006.** Joint Forest Management in India. Vol-I & II. Aavishkar Publication, Jaipur.

SECOND SEMESTER

Course Code: EMNRM-652 Practical

P: 4 T: 0 C: 2

Course Title: **REMOTE SENSING AND GIS**

Image Processing software:

1. Introduction to Erdas Imagine 2010 Software
2. Digital Image classifications (Supervised and unsupervised)
3. Georeferencing (Scanned topographical sheets and Image to image)
4. PAN sharpening or multi-sensor image merging (fusion)
5. Mosaic

GIS software:

1. Introduction to ArcGIS ArcInfo10 software
2. Practicals related to different functions of the software
3. Generation of Geodatabase including incorporating different attribute data and final map composition
4. Integration of raster and vector data
5. Case studies – urban planning, forestry application, environment/disaster management

Books Recommended:

Text Book:

1. **Gorr, Wilpen L., Kristen S. Kurland. 2010.** GIS Tutorial 1: Basic Workbook for ArcGIS 10. (note there are other tutorials continuing the GIS instructions).
2. **Kaplan, Elliot D., and Christopher Hegarty. 2005.** Understanding GPS: Principles and Applications, Second Edition. Artech.

SECOND SEMESTER

Course Code: EMNRM-654

P: 4 T: 0 C: 2

Course Title: COMPUTER BASED STATISTICAL ANALYSIS IN NRM

Software to be used: SPSS, Minitab, Excel

Data analysis and interpretation: (How statistical tools are useful in various resource conditions, how to decide which tools to be used and when)

- a) Samples, population, and variables: parameters and statistics
- b) Graphical representation of statistical data using frequency distribution, box plots, scatter diagrams and individual value plots
- c) Various measures of central tendency and dispersion
- d) Hypothesis testing and confidence interval measurement
- e) Assumptions, properties and applications of various kinds of t tests (including 1 Sample, 2 Sample and paired t test)
- f) Chi square test and its distribution, goodness of fit
- g) Nonparametric parameters such as the Mann – Whitney test
- h) Hypothesis testing and correlations between parameters
- i) Regression analysis and fitting of data in linear equation
- j) One way ANOVA and Two Way ANOVA
- k) Multivariate analysis
- l) Principal Component Analysis (PCA)

Recommended Books:

Text Book:

1. **Chandel S.R.S.** A textbook of Agricultural Statistics.
2. **Dean, Angela and Daniel Voss.** Design and Analysis of Experiments. Springer.

Reference Book:

1. **Cochran, W.G. and G.M. Cox.** Experimental Designs. Wiley Publication.
2. **Pallant, Julie. 2010.** SPSS Survival Manual. Kindle Edition.
3. **MacDonald, Matthew. 2010.** Excel 10: The Missing Manual. O'Reilly Media.

SECOND SEMESTER

Course Code: EMNRM-656

P: 4 T:0 C:2

Course Title: **VEGETATIONAL INVENTORY AND RAPID ASSESSMENT: TOOLS AND TECHNIQUES**

Vegetation Inventory: goals and overall methods, grasslands, forests, assessing habitat quality vs. species richness

Participatory Rural Appraisal Methods (PRA): resource mapping, historical transects, land use transects, matrix ranking and scoring, temporal analysis vs. seasonality analysis

Techniques: evaluating species richness, species evenness, biomass in grasslands, biomass in forests –qualitative vs. quantitative methods; 32tilization32 profiles, canopy measurements of structure and cover, tree and leaf biomass, transect methods, quadrat sampling methods for Vegetational study –density, frequency, abundance. Forest carbon assessment.

Recommended Books:

Text Book:

1. **Mishra, R.** Forest Ecology Field Manual.
2. **Brower, James, John Zar, and Carl N. von Ende. 1997.** Field and Laboratory Methods for General Ecology. McGraw – Hill.

Reference Book:

1. **Poffenberger, M., Betsy McGeen, N.H. Ravindranath and MadhavGadgil, editors. 1992.** J. Society of Promotion of Wasteland Development.
2. **Ravindranath, N.N.** Carbon Inventory Method.Springer – Verlag.

THIRD SEMESTER

Course Code: EMNRM-701

L: 3 T: 0 C: 3

Course Title: **FINANCIAL ANALYSIS, PROJECT MANAGEMENT AND PLANNING**

UNIT-I

Financial analysis: Introduction to financial management: planning and forecasting, cost to volume profit analysis, working capital management, problems.

Management of receivables, assets and liabilities, cost of capital, operating and financial leverages, capital structure, and international financial management

UNIT-II

Project Management: Formulation, financing, implementation and control, project management including product cycles and logical framework analysis, exploration and screening, techno-economics, feasibility reports (marketing, technical, financial, and risk analysis)

Microfinance and micro credit concept and their application in rural development and livelihood generation.

UNIT III

Project identification and presentation: Socio-economic consideration in project formulation, social infrastructure projects for sustainable development, investment opportunities, project screening and presentation for decision making, capacity expansion, diversification

Project costs and Finances: Calculating project costs, production costs, break-even analysis, financing methods, tax aspects, role of the financial institution in project finance. Strategic Management.

Recommended Books:

Text Book:

1. **Bhavesh, M. Patel. 2000.** Project Management: Strategic Financial Planning Evaluation and Control. Vikas Publishing.
2. Prasana Chandra, (2007). Financial Management: Theory and Practice. McGraw Hill.

Reference Book:

1. **Rashkonen, E., editor. 1997.** Managing Risk in Projects. E&FN Spon.
2. **Wysochi, Robert K., Bick Robert and David B. Crane. 2000.** Effective Project Management. John Wiley.
3. **Ezra, Solomon and John J. Pringle.** An Introduction to Financial Management. Prentice Hall of India.
4. **Goodman, Louis J. 1988.** Project Planning and Management: An Integrated System for Improving Productivity. Von Nostran Reinhold.
5. **Robinson S. Marguerite 2001.** The Microfinance revolution: Sustainable Finance for the Poor. The World Bank, Washington, DC.

6. Wysocki, R. K. http://www.amazon.com/Effective-Project-Management-Traditional-Extreme/dp/111801619X/ref=pd_sim_b_1/179-8977351-3681336(2011). Effective Project Management: Traditional, Agile, Extreme. Wiley International. 816 pp.

THIRD SEMESTER

Course Code: EMNRM-703

L: 3 T:0 C:3

Course Title: **CLIMATE CHANGE AND CARBON TRADING**

UNIT-I

Energy issues and climate change: Greenhouse effect as a natural phenomenon, greenhouse gases (GHGs) and their sources, quantifying CO₂ and methane emissions, global warming potential (GWP) of GHGs

Impacts of climate change in different ecosystem: Models of global and Indian changes including temperature rise, sea level rise, coastal erosion and flooding, positive feedbacks, Climate change refugees

UNIT-II

Controlling carbon dioxide: Efforts to restrict carbon dioxide levels: Kyoto Protocol, recent protocols, methods to increase carbon dioxide absorption such as power production, agricultural production, forestry, and industry, the Copenhagen Summit and its implications, future predictions

Carbon Trading: The concept of carbon credits, standard and branded credits and mechanisms, alternative trading models (European, Indian), global and Indian scenarios

UNIT-III

Carbon sequestration: conventional and non-conventional techniques, carbon sequestration in vegetation deep saline aquifers, ocean carbon absorption, alternatives and risks

Strategic management of carbon emissions: Future predictions, Best Management Practices, types of certification, and case studies related to global warming and its control in different ecosystem, REDD and REDD⁺ mechanism.

Recommended Books:

Text Book:

1. **Brohe, Arnaud, Nick Eyre, and Nicholas Howarth. 2009.** Carbon Markets: An International Business Guide (Environmental Market Insights). Routledge.
2. **Labatt, Sonia, and Robert R. White. 2007.** Carbon Finance: The Financial Implications of Climate Change (Wiley Finance). Wiley Finance.

Reference Book:

1. **Esty, Daniel C., and Andrew Winston. 2009.** Green to Gold: How Smart Companies Use Environmental Strategy to Innovate, Create Value, and Build Competitive Advantage. Wiley.

THIRD SEMESTER

Course Code: EMNRM-705

L: 3 T:0 C:3

Course Title: **AGRO-ECOSYSTEMS AND AGRO-FORESTRY**

UNIT-I

Concept & Scope in Agroecosystem and Agroforestry- Concept Agro-ecosystem, various parameters of agro-ecosystem and sustainability. Agroforestry. Classification of Agroforestry Systems. Types of Agroforestry Systems – Agrisilviculture, Agrosilvopasture, Alley Cropping, Hortisilviculture, Nutritional Garden. Plantation Models for AF. Traditional Agroforestry Systems in India- Homestead, Taungya system, Shifting cultivation and Boundary plantation. Agroforestry Practices existing in India.

Land Management -. Land use Pattern of Indian Farmers, Land use Classification and Planning. Dynamics of soil fertility and farming. Field Survey Methods for soil Soil and moisture conservation measures: Factors associated to crop selection and cropping pattern. Concept of zero tillage and organic agriculture.. Biofuel plantation in wasteland areas – Problems and Prospects.

Importance in land management.

UNIT-II

Technical Agroforestry Applications – Multipurpose Trees and Shrubs (MPTS) in Agro – forestry. Bamboo, fuelwood & fodder trees. Choice of species for Agro forestry. Few important species for Agro-forestry. Agroforestry Management. Role of Nitrogen fixing trees and shrubs in Agro-forestry, Bio-fencing models. Role of Bio-fertilizer (Mycorrhiza) in Agroforestry, Allelopathy & its role in Agroforestry. Designing Agroforestry Model – Experimental Agroforestry: Diagnosis & Design Techniques Handling of Agroforestry Seeds for Nursery and Plantation Exercise: Agroforestry Model Designing. Risk associated with Monoculture. Integration of Agroforestry with Other Systems. Agroforestry Issues, Research needs.

UNIT-III

Integrated Agroforestry System – Scope of Energy Plantations, horticulture, apiculture and sericulture along with agroforestry. Agroforestry Practices and learning from developing countries – Sri Lanka, Bangladesh, Pakistan, Nepal, Indonesia, Philippines and China Film Show on Agroforestry Practices.

Agroforestry based case discussion: Topic focus:

- Alternative to Jhum / Podu / Shifting Cultivation in Orissa (Koraput District)
- Private Forestry (LokVaniki Project) in Madhya Pradesh
- Private Sector Participation in Agroforestry: WIMCO & ITC's effort – Poplar and Eucalyptus based agroforestry
- The Krui Agroforests of Indonesia: A model of sustainable community-based management- Policy Analysis.
- Carbon sequestration: An underexploited environmental benefit of agroforestry systems.

Recommended Books:

Text Book:

1. **L. K. Jha 1995.** Advances in Agroforestry. Ashish Publisher House, New Delhi.
2. **P. Dwivedi 1992.** Agroforestry Principles and Practices. Oxford and IBH Publishers, New Delhi.

Reference Book:

1. **K. Bandyopadhyay 1997.** A textbook of Agroforestry with Applications. Vikas Publications, New Delhi.
2. **Anil Kumar 1989.** Wasteland Management in India. Ashish Publishing House, New Delhi.
3. **L.K. Jha and P.K. Sen Sharma.** Agroforestry in Indian perspective
4. **Panjab Singh, P.S. Pathak, M.M. Roy 1996.** Agroforestry Systems for Degraded Lands.
5. **Chuhdawat, Gautam 1993.** Textbook of Agroforestry. Oxford and IBH Publishers, New Delhi

THIRD SEMESTER

Course Code: EMNRM-707

L: 3 T:0 C:3

Course Title: **WILDLIFE CONSERVATION AND MANAGEMENT**

UNIT-I

Introduction and history of wildlife conservation: Global and Indian perspectives, the history of wildlife conservation and how it has shaped conservation today, modern concepts such as the Protected Area Network (PAN), IUCN, and CITES. Wild plants and wild relatives of crop plants.

Values and ethics in wildlife conservation: Definitions and traditions (instrumental, intrinsic, ecocentrism, religious traditions and conservation), Aldo Leopold's land ethic and ethics in conservation.

UNIT-II

Ecology theory: Habitat ecology and the concept of habitats from microhabitat to biosphere, range, area of occupancy, niche theory and resource partitioning.

Wildlife behavior: Group living, selfishness and altruism, evolutionarily stable strategies, concept of optimality in animal decision making, optimal foraging theory

UNIT-III

Current issues in wildlife conservation with case studies: Community based conservation vs. rare species conservation, impact of climate change, payment for ecological production of environmental services, human-wildlife conflict, poaching, illegal trading, conflict management and shifting from extraction to preservation

Wildlife management: Population Viability and Habitat Analysis (PVHA), captive breeding and propagation, rescue, rehabilitation and reintroduction, gene banks, ex-situ and in-situ conservation. Forest landscape restoration and importance of microorganisms.

Recommended Books:

Text Book:

1. **Caughley, G., and A.R.E. Sinclair, editors. 1994.** Wildlife Ecology and Management, Blackwell Science.
2. **Sutherland, W.J. 2000.** The Conservation Handbook: Research, Management and Policy. Blackwell Sciences.

Reference Book:

1. **Bookhout, T.A. 1996.** Research and Management Techniques for Wildlife and Habitats, 5th edition. The Wildlife Society, Allen Press.
2. **Buckland, S.T., D.R. Anderson, K.P. Burnham and J.L. Laake. 1993.** Distance Sampling: Estimating Abundance of Biological Populations. Chapman & Hall, reprinted (1999) by Research Unit for Wildlife Population Assessment, St. Andrews.

3. **Woodroffe R., S. Thirgood and A. Rabinowitz. 2005.** People and Wildlife, Conflict or Co-existence? Cambridge University.
4. **Caughley, G. 1977.** Analysis of vertebrate populations. John Wiley and Sons.
5. **Hunter M.L., J.B. Gibbs and E.J. Sterling. 2008.** Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.
6. **Rangarajan M. 2001.** India's Wildlife History. Permanent Black.
7. **Krebs, C. J. 1999.** Ecological Methodology, 2nd edition. Addison-Wesley Educational Publishers.
8. **Sutherland, W.J., I. Newton and R.E. Green. 2004.** Bird Ecology and Conservation: A Handbook of Techniques. Blackwell Sciences.

THIRD SEMESTER

Course Code: EMNRM-709

L: 3 T: 0 C: 3

Course Title: **RESEARCH METHODOLOGY AND DEVELOPMENT COMMUNICATION**

UNIT-I

Research design: Types of research, phases and stages of research, developing a hypothesis or research idea, writing about research, designing the research protocol, choosing method for data analysis.

Parameter identification and hypothesis testing: Hypothesis refinement, measurable parameters, estimation of precision needed, null and alternate hypotheses, measurements of variation, type 1 and type 2 errors, significance tests

UNIT-II

Sampling and principles of measurement: Types of sampling, probability and non-probability sampling, methods of drawing random samples, variables, good sampling methods, sample size, sampling error, measurement scales, types of data and distributions

Application: Good experimental design, writing the research proposal, planning for the anticipated results.

Development communication (DC) – background, forms of DC, Application of DC.

UNIT-III

Introduction to scientific communication: Ethics in scientific writing and publishing, theory and importance of scientific communication, scientific communications between scientists both traditional and modern, and communication with the public, logical organization of scientific data

Different components of scientific and technical communications: Research articles vs. reviews, components of the research paper and the hypothesis, proposal writing, understanding the nature and philosophy of the funding agency, writing about budgeting and unitization, peer reviewing, posters and oral presentations at scientific meetings, writing reports and theses

Writing for the non-scientific community: Extension and outreach of scientific information, oral presentations, scientific journalism, science issues in the public domain and the public conception of science (explanation with case studies)

Recommended Books:

Text Book:

1. **Bucchi, M. and B. Trench, editors. 2008.** Handbook of Public Communication of Science and Technology. Routledge.
2. **Bella Mody 2001** Designing Messages for Development Communication –An Audience participation-based approach. SAGE Publications.

Reference Book:

1. **Robert, A.D. and G. Barbara. 2006.** How to Write and Publish a Scientific Paper, 6th Edition. Cambridge University Press.
2. **Soraya, M.C. and A.S. Cynthia. 2001.** Proposal Writing. Sage Publications.
3. **Gregory, J. and S. Miller. 1998.** Science in Public: Communication, Culture and Credibility. Plenum.
4. **Holliman, R., et al., editors. 2009.** Investigating Science Communication in the Information Age: Implications for Public Engagement and Popular Media. Oxford University Press.
5. **Nelkin, D. 1995.** Selling Science: How the Press Covers Science & Technology, 2nd Edition. WH Freeman.
6. **Hoffmann, Angelika H. 2009.** Scientific Writing and Communication: Papers, Proposals, and Presentations. Oxford.
7. **Field, Anthony. 2003.** How to Design and Report Experiments. Sage Publications.
8. **Glass, David. 2006.** Experimental Design for Biologists. Cold Spring Harbor Laboratory Press.
9. **Underwood, A.J. 1997.** Experiments in Ecology: Their Logical Design and Interpretation Using Analysis of Variance. Cambridge.

THIRD SEMESTER

Course Code: EMNRM-751

L: 3 T:1 C:4

Course Title: **URBAN FORESTRY, BIODIVERSITY AND LANDSCAPE**

UNIT-I

Concepts: Urban greens, landscape, urban forestry and biodiversity, global perspectives of urban forestry, human dimensions, urban forests and climate change, migration, Urban poverty and livelihood. Environmental problems in urbanizing world. Ecological social – economic functions, health, cultural, recreation values, urban planning, benefits, linking forest and vegetation. Concept of sustainable cities and green space.

UNIT-II

Urban biodiversity: Loss of Urban Biodiversity. Species choice, flowering and evergreen trees and shrubs, floral and faunal diversity. Threats and significance of Urban biodiversity in India, characteristics of selected urban forestry species, significance of biodiversity parks, urban biodiversity register (UBR), wildlife habitat design.

UNIT-III

Management of urban forest landscape: Urban landscape elements. Technical aspects of tree maintenance-pruning, cleaning, post plantation care, cleaning, nursery, water management. Types of plantation, design & tree architecture, monitoring, urban forestry management issues, stake holder's analysis.

UNIT-IV

Urban forestry planning policy and application: Integration of urban forestry in city planning, institution policy and social issues, incentives and partnerships, contribution of urban forests in generating livelihoods for urban poor in India, governmental role, NGO roles, corporate houses and civil society organizations, urban green space development, synthesis and directions for future research, planning and implementation in urban forestry and biodiversity. Restoring ecological functioning of urban forests, methods and results.

Recommended Books:

Text Book:

1. **Grey, G.W., and F.J. Denke. 1986.** Urban Forestry. Wiley Publication.
2. **Miller, R.W. 1997.** Urban Forestry: Planning and Managing Urban Green Spaces, 2nd edition. Prentice Hall.

Reference Book:

1. **Konjendijk, ?, et al. 2005.** Urban Forests and Trees. Springer.
2. **Kuchelmeister, G. 1998.** Urban Forestry in the Asia – Pacific Region: Status and Prospects. APFSOS Working Paper #44, Food and Agriculture Organization.
3. **Bradley, Gordon A., (editor)** Urban Forest Landscapes: Integrating Multidisciplinary Perspectives.

THIRD SEMESTER

Course Code: EMNRM-753

L: 3 T:1 C: 4

Course Title: **WETLAND MANAGEMENT**

UNIT-I

Wetlands: Definitions, origin of wetlands, types, wetland classification systems, Ramsar Convention, Ramsar sites in India)

Wetland ecosystems ecology: Freshwater, marine, estuarine, with respect to hydrology, productivity, detrital accumulation, and biodiversity, biological adaptations to the wetland environment (plants and animals)

UNIT-II

Wetlands biogeochemistry: Nutrient cycling (carbon, phosphorous, nitrogen), eutrophication, Trophic State Index, greenhouse gas emissions, methanogenesis- paddy field, carbon sequestration, carbon models, wetlands as treatment filters, wetlands and climate change, permafrost

UNIT-III

Wetland bioassessment and biocriteria: biological assemblages, Index of Biological Integrity (IBI), functional assessment of wetlands

Wetland conservation and action plans: Landscape ecology, wetland metrics, rate of wetland loss, wetlands catchments and water storage, wetlands and flood control, GAP analysis, wetland conservation in India, Management effectiveness of Ramsar sites, national parks and bird sanctuaries, wetland regulations. Add few case studies

UNIT-IV

Remote sensing and GIS applications: Wetland inventories, information systems, biodiversity conservation, greenhouse gas emissions, nutrient cycling, measuring wetlands loss

Recommended Books:

Text Book:

1. **Mitsch, W.J. and J.G. Gosselink, 2007.** Wetlands, 4th edition, John Wiley & Sons.
2. **Van Der Valk, Arnold G., and Arnoud Van Der Valk. 2012.** The Biology of Freshwater Wetlands. Oxford University.

Reference Book:

1. **Odum, Edward U. 1973.** Fundamentals of Ecology, 3rd Edition, W.B. Saunders.
2. **Maltby, Edward, and Tom Barker. 2009.** The Wetlands Handbook, Wiley – Blackwell.
3. **Reddy, K. Ramesh, and Ronald D. Delaune. 2008.** Biogeochemistry of Wetlands: Science and Applications, CRC.

THIRD SEMESTER

Course code: EMNRM-755

L: 3 T:1 C:4

Course Title: **ADVANCED REMOTE SENSING AND GIS**

UNIT-I

Contemporary concepts in geospatial technology: Advanced RS sensors and satellites, hyperspectral remote sensing, soft copy photogrammetry, thermal remote sensing: thermal inertia, LST and SST, RADAR interferometry, Knowledge-based classifiers, object oriented classification, Open source GIS, mobile and cloud-based GIS

Landscape ecology and GIS: Landscape elements, typology of patches and corridors, landscape dynamics, fragmentation, disturbance, spatial statistics, natural resources management

UNIT-II

Ecosystem analysis and management: Forest types and forest inventory, volume and biomass estimation, biodiversity estimation, habitat suitability and protected area management, grassland ecosystems, aquatic ecosystems, wetland classification, biodiversity conservation.

Marine and coastal zone ecosystems: Sea Surface Temperature (SST), fisheries forecasting, coastal zone management, pollution monitoring.

Environmental Impact Assessment: Assessment needs and RS compliance, major developmental activities and RS indicators, rehabilitation of brownfields and industrially disturbed areas.

UNIT-III

Environmental hazards: Forest fires, desertification, floods, soil erosion modeling, river pollution, earthquakes, tsunamis, cyclones, landslide hazard zonation, disaster management and risk modeling

Water Resources: Surface water monitoring and water quality assessment

Urban resources: Urban land use, urban green spaces, facility mapping, site selection for solid waste management, sewage treatment site selection

UNIT-IV

Accuracy assessment: Classification, positional and spatial, contingency tables, kappa coefficient and accuracies

Project Formulation and Execution: Objective definition, satellite data selection, thematic map(s) preparation, integration of RS, GIS and GPS, spatial and non-spatial database standards, spatial database creation, errors in geospatial data, information systems

Case studies and future predictions: cases, drones, future possibilities, integrating remote sensing into other technology

Recommended Books:

Text Book:

1. **Lo, C.P., and Albert K.W. Yeung. 2009.** Concepts and Techniques of Geographic Information Systems, 2nd Edition. PHI Learning Private Limited.

2. **Joseph, George. 2005.** Fundamentals of Remote Sensing, 2nd Edition, Universities Press Limited.

Reference Book:

1. **Jensen, John R. 2009.** Remote Sensing of the Environment: An Earth Resource Perspective, 2nd Edition, Dorling Kindersley Private Limited.
2. **Lillisand, Thomas, Ralph W. Kiefer, and Jonathan Chipman. 2007.** Remote Sensing and Image Interpretation. Wiley India.
3. **Sabins, Floyd F. 2007.** Remote Sensing: Principles and Interpretation. Waveland Press.
4. **Jensen, John R. 2004.** Introductory Digital Image Processing: A Remote Sensing Perspective. Prentice Hall.
5. **Burrough, P.A. 2007.** Principles of Geographical Information System. Oxford University Press.

THIRD SEMESTER

Course Code: EMNRM-757

L: 3 T:1 C:4

Course Title: **ENVIRONMENTAL MODELLING**

UNIT-I

Introduction to environmental modeling: Overview of different types of models (mathematical, both stochastic and numerical, physical, computer simulations), 46 modelling concept need and scope, calibration and verification of models, 46modelling imitations, models and decision-making. Model development and decision making.

Water quality modeling: Historical perspective, water quality models, surface vs. groundwater modeling.

UNIT-II

Lakes: Steady state solutions, completely mixed systems, concept and models in Completely Stirred Tank Reactors, mass balance equations, loading types, feed forward vs. feedback reactor systems, incompletely mixed system

UNIT-III

Moving water: Contaminant 46 modelling in rivers, streams and estuaries, dissolved oxygen (DO), DO sag, biological oxygen demand (BOD), Streeter Phelps equations for point and distributed sources, eutrophication in flowing water

UNIT-IV

Ground Water Modelling: Overview, Darcy's Law

Air quality: Historical perspective, objectives and application of air quality models, approaches to model building, model classification, gradient transport models, eddy diffusion models, Gaussian Plume models (point, line and area)

Recommended Books:

Text Book:

1. **Hipel, K.W and A.I. McLeod. 1994.** Time Series Modelling of Water Resources and Environmental Systems. Elsevier Science.
2. **Zanneti, P. 1990.** Air Pollution Modeling Theories, Computational Methods and Available Software. Van Nostrand Reinhold, New York.

Reference Book:

1. **Thomann, R.V. and J.A. Mueller. 1987 .**Principles of Surface Water Quality Modelling and Control, Harper and Row.
2. **Chapra, S.C. 1997.** Surface Water Quality Modeling, McGraw-Hill.
3. **Benaarie, M.M. 1980.** Urban Air Pollution Modelling.MIT Press.

THIRD SEMESTER

Course Code: EMNRM-759

L: 3 T:1 C:4

Course Title: **ECOTOURISM AND OTHER ENVIRONMENTAL SERVICES**

UNIT-I

Concept of environmental services: Definitions, ecotourism, alternative examples, development of ecotourism in India and outside. Threats due to large scale ecotourism.

Payment for Ecosystem Services (PES), REDD+ in PES.

UNIT-II

The ecotourism dilemmas: High value may also be high impact, bulk ecotourism and problems, stakeholder challenges, tourist carrying capacity.

Ecotourism Policy and practices, national policy frame work, example – Madhya Pradesh & Uttarakhand State case. Successful ecotourism initiative, Criteria and Indicators for sustainable Ecotourism.

UNIT-III

Ecotourism alternative services: sustainable extraction, extraction impacts, community involvement and compensation, shift from consumption to sustainable management.

UNIT-IV

Case studies: Ecotourism in protected areas of India and abroad, Payment for Ecosystem Services (PES), ecotourism in coastal areas, village ecotourism, herbal ecotourism in Kerala, wildlife area ecotourism.

Recommended Books:

Text Book:

1. **Honey, Martha. 2008.** Ecotourism and Sustainable Development: Who Owns Paradise? 2nd edition. Island Press.
2. **Seema Bhat & Syed Liyakhat 2008.** Ecotourism Development in India: Communities, Capital and Conservation published by CEE, Ahmedabad

Reference Book:

1. **Patterson, Carol, Delia Owens, and Mark Owens. 2007.** The Business of Ecotourism. Trafford Publishing.
2. **Collier, Paul and Anthony J.J. Venables. 2011.** Plundered Nations?: Successes and Failures in Natural Resource Extraction. Palgrave MacMillan.

THIRD SEMESTER

Course Code: EMNRM-761

L: 3 T:1 C:4

Course Title: **BIO-RESOURCES**

UNIT-I

Introduction to Bioresources: Bioresources concept and definition, endemic bioresources of India, ecological principles for managing bioresources, ethical and historical aspects of bioresources. High Value species of commercial importance- spices, aromatics.

Species diversity: Wild taxa, species inventorying and problems, plants, animals and microbes , compare species diversity between different sites.

UNIT-II

Microbial resources: forms and their importance in business application by the industry.

Bioresource extraction and utilization: Forest resource diversity and documentation, timber and non-timber (NTFPs) products ,economic value, industrial forestry uses, aromatic resources, essential oils and spices, perfumery products.

UNIT-III

Medicinal plants: Drugs from nature, present developments and future prospects, Citrus and Sarcomelicope species as models for new anti-tumour agents

Marine bioresources: Biofuel from algae, Diversity and Documentation, industry, management and utilization of marine bioresources-types.

Bioresources and people: Case studies from India, palm oil cultivation and uses as bioresources

UNIT-IV

Biotechnology and Bioresources: Biotechnology processes and bioresources, utilization, assessment, and sustainable uses, biosafety and bioethics, indigenous knowledge and bioprospecting, ethnobiology and the conservation of dwindling bioresources. Bioresource enterprise, livestock resources.

Sustainable Utilization: Ecological, legal and social frameworks, ethics of sustainable utilization, bioresources for food security and rural livelihood, bioresources and the global human economy

Recommended Books:

Text Book:

1. **King, A., H. Cleveland and G. Streatfeild. 1980.** Bioresources for development: The renewable way of life. Pergamon Press.
2. **Ananthkrishnan, T.N. 1989.** Bioresources Ecology. Oxford and IBH.

Reference Book:

1. **Krishnamurthy, K.V. 2009.** An Advanced Textbook on Biodiversity Principles and Practice.Oxford and IBH.

2. **Singh, M.P and S. Dey. 2004.** Bioresources and Genepool Conservation. Daya Publishing.
3. **Shiva, M.P. 1998.**Inventory of Forest Resources for Sustainable Management and Biodiversity Conservation.Indus.
4. **Marshall, E., K. Schreckenber, and A.C. Newton, editors. 2006.** Commercialization of Nontimber Forest Products. UNEP World Conservation Monitoring Centre.
5. **Vertes, A.A., N. Qureshi,, H.P. Blaschek and H. Yukawa, editors. 2009.** Biomass to Biofuels: Strategies for Global Industries. Wiley.
6. **Iversen, E.S. 1996.** Living Marine Resources: Their Utilization and Management.Chapman and Hall.

THIRD SEMESTER

Course Code: EMNRM-763

L: 3 T:1 C: 4

Course Title: **WATERSHED MANAGEMENT**

UNIT-I

Definition and scope: Concept, delineation from topographical maps, remote sensing and GIS mapping, watershed problems and characteristics, types, important objectives in management and development

UNIT-II

Characteristics: Landuse, vegetation, drainage, morphometry, climate, soils, geology, slope and aspect, socio-economic classification, soil erosion and estimating the soil loss erosivity index, Universal Soil Loss Equation (USLE)

UNIT-III

Hydrology: Hydrological cycle, drainage system, classifications characteristics of water resources, surface runoff, stream flow estimation, erosion control, water conservation, people and local uses

UNIT-IV

Planning and management: Watershed management, multi-objective planning, erosion control, water conservation measures, resource use patterns, people participation, work plans, integrated watershed development, monitoring, watershed management missions and evaluation of management activities, risks,

Case studies – Analysis of various dimensions of Watershed Management

Recommended Books:

Text Book:

1. **Singh, Rajvir. 2000.** Watershed Planning and Management. Yash Publications.
2. **Murthy, V.V.N. and M.K. Jha. 2009.** Land and Water Management, 5th edition. Kalyani Publishers.

Reference Book:

1. **Murthy, V.V.N.** Land and Water Management. Kalyani Publishers.
2. **Heathcote, I.W. 1988.** Integrated Watershed Management: Principles and Practices. John Wiley and Sons.
3. **Ragunath, H.M. 2007.** Hydrology: Principles, Analysis and Design, 3rd edition. New Age International.
4. **Das, Ghanshyam.** Hydrology: Soil Conservation and Watershed Management. PHI.

5. **Suresh, R. 2009.** Soil and Water Conservation Engineering, 2nd revised edition. Standard Publishers.

FOURTH SEMESTER

Course Code: EMNRM-702

Credits: 4

Course Title: SEMINAR AND PROGRESS REPORT³

Course Code: EMNRM-704

Credits: 22

Course Title: DISSERTATION⁴

³ Evaluation will be based on the report and a presentation in the presence of at least three faculty members of the School duly approved by the Vice-Chancellor.

⁴ The student will submit a synopsis in a specified format at the beginning of the semester, to be evaluated for approval by the departmental committee. The student will have to present the progress of the work through seminars and progress reports. Evaluation of the dissertation will be based on thesis and viva/voce by the Board of Examiners comprising of the External Expert and the Internal Supervisor. The names of the External Examiners shall be approved by the Vice-Chancellor by the recommendations of the Dean.

Total No. of Credits offered in all four semesters⁵- 105

⁵ The student will require to earn 100 credits for the award of the degree. The student will not have the option to drop any course covered in the scheme of the examination he/she will be required to register all the courses listed in the scheme of the examination of the programme.

NOTATIONS

Theory

L- Lecture

T- Tutorials

P- Practical/Lab

1- Credit Theory Lecture + 1 Hour

1 Credit- Practical/Lab = 2 Hour

Paper ID for each course is to be obtained as

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Programme Code Course Code

For example Paper ID for the course BA 601 is

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Programme Code Course Code